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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of	:	
S. Joseph Campanella	:	Group Art Unit: 2731
Serial No.: 09/640,686	:	
Filed: August 18, 2000	:	
For: Method and Apparatus for Mobile Platform Reception and Synchronization in Direct Digital Satellite Broadcast System	:	

REQUEST FOR RETENTION OF DISCLOSURE DOCUMENT

Reference is made to the following Disclosure Document which contains subject matter related to that disclosed and claimed in the present application:

Number:	457067
Title:	Method and Apparatus for Transmission Synchronization Correction for Distance Between Terrestrial Stations in Satellite Reinforcement System
Date of Deposit:	May 28, 1999

In view of the filing of the present application, it is requested that the Disclosure Document identified above be designated for permanent retention. A copy of the Disclosure Document is attached for reference purposes.

Respectfully submitted,

Stacey J. Longanecker

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Reg. No. 33,952

Roylance, Abrams, Berdo & Goodman, L.L.P.
1300 19th Street N.W., Suite 600
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Dated: May 29, 2001

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WorldSpace Corporation

457067

DISCLOSURE DOCUMENT

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May 4, 1999

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Commissioner of Patents and Trademarks
Washington, D.C. 20231

Re: Submission of Disclosure Document for "Method and Apparatus for Transmission Synchronization Correction for Distance Between Terrestrial Stations in Satellite Reinforcement System"

Dear Sir:

The undersigned, Dr. S. Joseph Campanella, assignor to WorldSpace Corporation, is the inventor of the disclosed invention entitled "Method and Apparatus for Transmission Synchronization Correction for Distance Between Terrestrial Stations in Satellite Reinforcement System". The undersigned requests that the attached papers be accepted under the Disclosure Document Program, and that they be preserved for a period of two (2) years.

A check in the amount of $10.00 is attached to cover the required fee. Also attached is a duplicate copy of this document and a stamped, pre-addressed envelope for use by the U.S. Patent and Trademark Office in acknowledging receipt of this document.

Please send the acknowledgement of filing, and any other correspondence relating to this disclosure document, to counsel for WorldSpace Corporation at the following address: John E. Holmes, Roylance, Abrams, Berdo & Goodman, L.L.P., 1225 Connecticut Avenue, N.W., Suite 315, Washington, D.C. 20036.

06/07/1999 NHASSANI 00000044 CAMPANELLA S J
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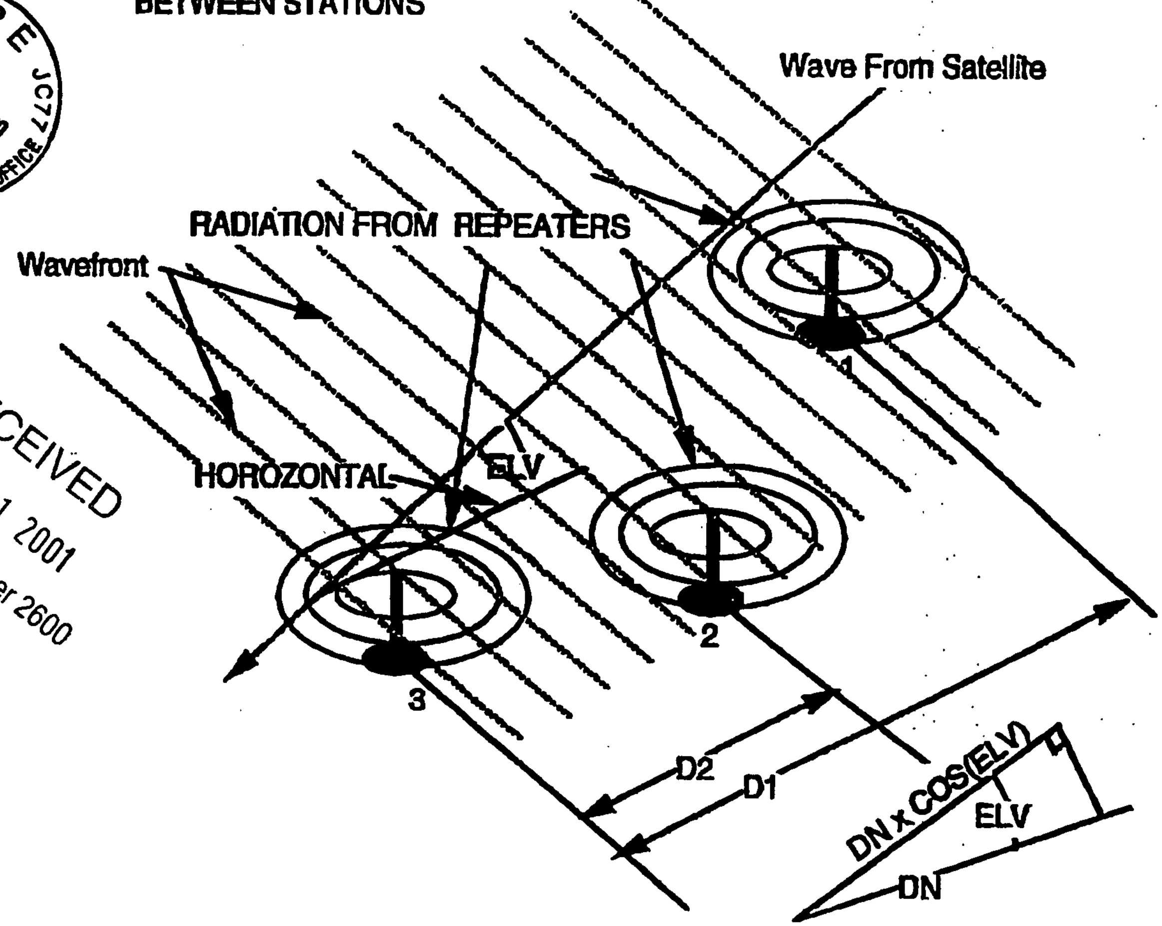
Respectfully submitted,

Dr. S. Joseph Campanella

TERRESTRIAL MCM STATION TRANSMISSION SYNCH CORRECTION FOR DISTANCE BETWEEN STATIONS



DN = DISTANCE OF TERRESTRIAL STATION N TO THE FARTHEREST STATION FROM THE SATELLITE WITHIN THE NETWORK COVERAGE. THIS DISTANCE IS MEASURED PARALLEL TO THE PROJECTION OF THE LINE-OF-SIGHT ON TO THE HORIZONTAL PLANE AND PERPENDICULAR TO THE WAVEFRONT. IN THE CASE SHOWN ABOVE THE FARTHEREST STATION IS # 3.

ELV = ELEVATION ANGLE TO THE SATELLITE OBSERVED FROM THE STATIONS OF THE NETWORK. NOTE THAT EACH STATION WILL HAVE A SLIGHTLY DIFFERENT ELEVATION ANGLE, BUT IN A TYPICAL REINFORCEMENT NETWORK THE DIFFERENCES ARE SO SMALL AS TO BE INSIGNIFICANT. HENCE, THE ELEVATION ANGLES CAN ALL BE ASSUMED TO BE EQUAL.

BASED ON THE ABOVE ASSUMPTIONS, THE SYNC. TIME CORRECTION, TN, FOR STATION N WILL BE:

TN = (DN x COS(ELV)) / c , WHERE c = SPEED OF LIGHT.

S.J. CAMPANELLA 03/18/99

RIPTION

isclosure pertains to a time correction that must be applied to the signal emitted from each terrestrial reinforcement nitter when the latter emitted signal is a replay of a signal distributed to all such terrestrial reinforcement stations fro mon geostationary or non-geostationary satellite source.

derstand the need for such time correction, realize that the signals retransmitted from the terrestrial stations must all a common instant of synchronization for their individual transmissions. Typically, for a terrestrial reinforcement networ ansmissions of the reinforcement signals must be synchronized to occur within 1 microsecond of one another for trial reinforcement network comprising typically from a few stations to as many as thirty and even more to operate efficiently. This is true for any terrestrial reinforcement waveform such as ones using MCM, OFDM, CDMA, FDMA, ive TDM or frequency hopping.

roblem arrises because the signal arriving from the common satellite source travels over different distances to the s terrestrial reinforcement stations. These differences in the satellite to terrestrial reinforcement station distances if rrected will appear as synchronization time differences among terrestrial signals and will seriously degrade or destroy fectivness of the terrestrrial reinforcement network.

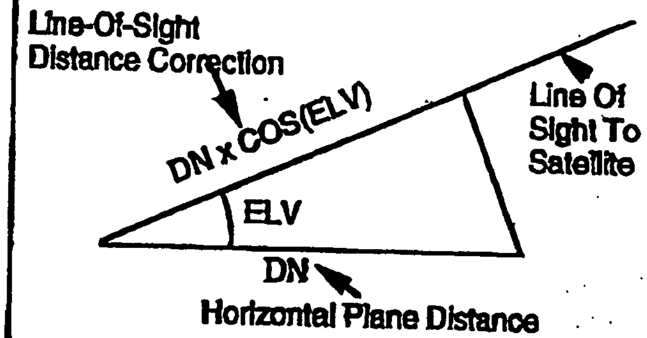
rrect the situation, a time delay of a precise magnitude determined by the elevation angle to the satellite and the ce differential to a particular terrestrial timing reference station (as identified below) must be injected into the ted signal path. The terrestrial timing reference station should be that one of the network which is at the greatest ce from the satellite. Consequently, to synchronize any other station, it is necessary to know that station's distance the terrestrial timing reference station along a line lying in the the horizontal plane of the earth, parallel to the ion of wave arrival and normal to the wavefront. Also the difference ΔHN in the height between the reference station tation N can have an influence on the timing correction.

l on the knowledge of DN, ΔHN, and ELV, and using the Geometry shown below, the time correction is given by

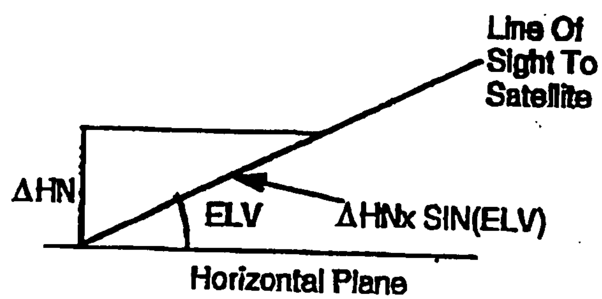
$$N = \{DN \times \cos(ELV) + \Delta HN \times \sin(ELV)\}/c$$

strate the magnitude of the effect, consider a case where DN = 10 km, ELV = 35°, $\Delta HN = 0$ m, and $c = 10^8$ m/s, then = 27.5µs. This magnitude of time difference is too great to remain uncorrected and must be compensated for by ting a delay of 27.5 µs in the transmission of the reinforcement signal from station N. delaying the If $\Delta HN = 30$ m ther ditional delay of .0574 µs. The latter is negligable. Only if a station is located on a very high mountain will the height rence be of concern.

CORRECTION DUE TO DN



CORRECTION DUE TO ΔHN



Alignment of TDM Frame symbol phase with the MCM Frame Symbol.

In MCM transport, a set of TDM frame symbols is supplied to an IFFT which assigns them to a set of MCM sub-carriers in an MCM symbol. Optimum operation of the MCM network requires that the same set of TDM symbols be carried in the same set of sub-carriers of each MCM symbol emitted by each repeater station of the network. Otherwise, constructive recovery at a receiver of the multiplicity over lapping MCM symbol arrivals coming from the various terrestrial stations is not possible.

A reinforcement network will typically comprise from 10 to 30 terrestrial reinforcement stations in selected geographic locations to cover a metropolitan area. Due to propagation delay differences from the satellite to the individual reinforcement terrestrial stations, the alignment of the TDM waveform symbols to the MCM symbols generated at the stations can be vary over a range of values sufficient to cause serious missalignments. For example, missalignments of as great as 138μs (i.e. 280 TDM symbol periods) can occur for a 40 km distance spread.

Even if all MCM symbol frames are precisely synchronized to the same time instant across all stations of the network, there will be misalignments of the TDM symbols with the MCM symbols ranging over various values up to a maximum (as cited in the example above) depending on the accidents of spacing and the azimuth and elevation angles of each station to the satellite.

Left uncorrected, the ensemble of MCM symbols arriving at a receiver will not contain the same TDM symbols in each of the MCM symbol sub-carriers. Literally, the TDM symbols will be jumbled up and the ability to constructively combine them destroyed.

By use of the alignment method described by the inventor, the TDM symbols can be appropriately aligned with the MCM symbols to eliminate the problem.

The alignment method works as follows :

1) Align the MCM symbol start times at all network stations to the high accuracy clock that can be recovered by a GPS receiver, By this means, the starts of all MCM symbols at the various stations of the network can be synchronized to within ± 1μs which is sufficient to achieve optimum reception at mobile receivers anywhere in the network.

2) At each station,introduce into the recovered bit level TDM waveform path a digital buffer of fixed length that is less by an amount equal to half an MCM symbol duration than the calculated differential delay time

3) Attach an adusfible delay section of maximum length equal to the width of the MCM symbol.

4) Using a digital TDM masterframe correlator, generate a TDM masterframe preamble spike.

5) Adjust the variable delay segment so as to cause the Master Frame Preamble correlation spike to coincide with the start time of the MCM symbol period. This can be accomplished within the granularity of one TDM symbol period automatically be the apparatus described below.

S. J. CAMPANELLA

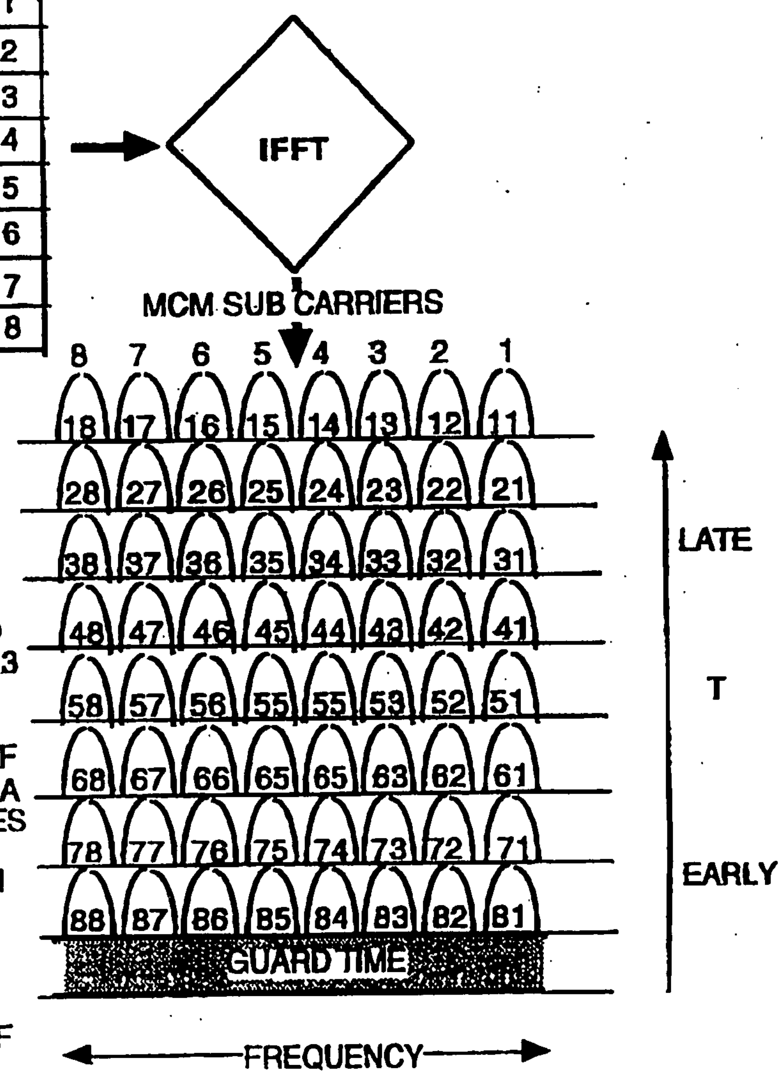
SYNCHRONIZATION OF TDM SYMBOLS TO MCM SUBCARRIERS

EARLY T LATE

TDM STREAM SYMBOLS

Properly Synchronized TDM

8	7	6	5	4	3	2	1
81	71	61	51	41	31	21	11
82	72	62	52	42	32	22	12
83	73	63	53	43	33	23	13
85	74	64	54	44	34	24	14
85	75	65	55	45	35	25	15
86	76	66	56	46	36	26	16
87	77	67	57	47	37	27	17
88	78	68	58	48	38	28	18



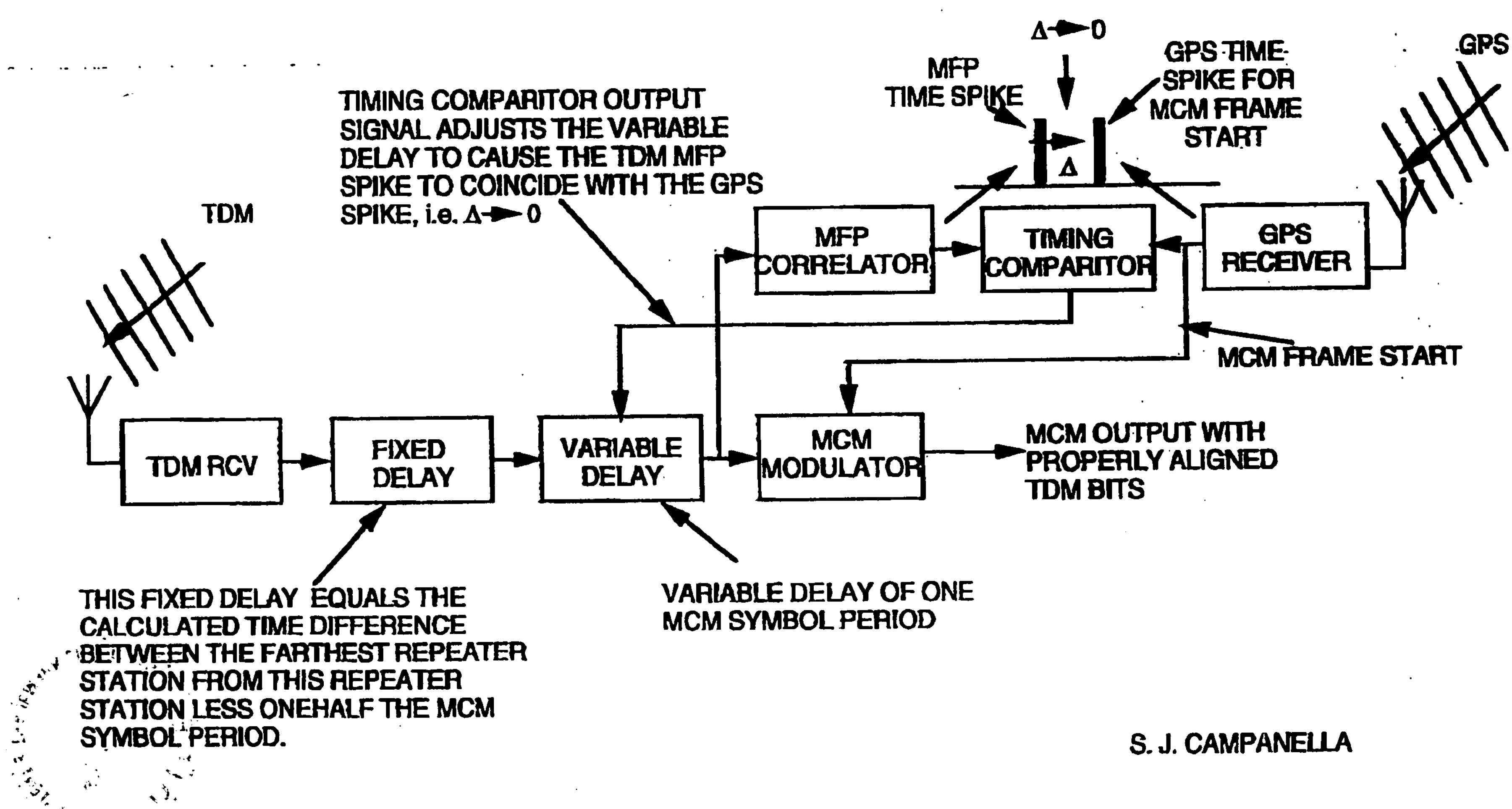
- THE SAME SYMBOLS OF THE TDM STREAM MUST BE <u>SIMULTANEOUSLY</u>ASSIGNED TO THE SAME MCM SUBCARRIERS AT ALL REPEATER STATIONS IN A TERRESTRIAL REINFORCEMENT NETWORK.

- IN THE EXAMPLE SHOWN HERE, THE TDM SYMBOLS OF COLUMN 1 ABOVE ARE ASSIGNED TO THE MCM SUB CARRIERS OF ROW 1 , 2 TO 2 , 3 TO 3 AND SO ON AS SHOWN AT THE RIGHT.

- BECAUSE TDM ARRIVALTIME DIFFERENCES OF OVER 100 µs OCCUR AMONG THE STATIONS OF A NETWORK DUE TO THEIR DIFFERENT DISTANCES FROM THE SATELLITE, INDIVIDUAL TIME PHASE CORRECTIONS MUST BE INTRODUCED AT EACH TO ACHIEVE THE SAME TDM SYMBOL TO MCM SUB CARRIER ALIGNMENT AT ALL STATIONS.

- AT EACH STATION THE TIME DIFFERENCES MUST BE MAINTAINED TO WITHIN A QUARTER OF A SYMBOL PERIOD TO MAINTAIN PROPER TDM SYMBOL TO MCM SUB CARRIER ALIGNMENT

APPARATUS FOR ALIGNING RECEIVED SATELLITE TDM SYMBOLS TO THE SUB-CARRIERS OF THE MCM FRAME



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